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STUDIES ON THE COCCACEAE

IV. THE CLASSIFICATION OF GENUS *MICROCOCCUS* COHN

G. J. HUCKER

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G. J. HUCKER

SUMMARY

The micrococci, staphylococci, and rhodococci are placed in a single genus which is called *Micrococcus* Cohn. The synonymy of this genus shows that these organisms have been, at various times, placed in a variety of genera, the characters of which have often been too meagrely described.

By use of the characters found applicable for the separation of species in an earlier report the following species have been described: *M. luteus, M. varians, M. flavus, M. conglomeratus, M. citreus, M. albus, M. candidus, M. epidermidis, M. tetragenus, M. ureae, M. freudenreichii, M. casei, M. aureus, M. aurantiacus, M. roseus,* and *M. cinnebareus.*

INTRODUCTION

In the foregoing sections of this report (Technical Bulletins Nos. 99, 100, and 101 of this Station) it has been pointed out that the irregular mass-forming cocci are a homogeneous group and may well be placed in one genus. A study of the characters of a long series of cultures included in this group failed to show any correlation of characters which could be used satisfactorily in forming subdivisions. However, the constancy of the results secured from various tests indicated that this genus is composed of quite distinct and easily recognized species.

This section of the series of reports dealing with the Coccaceae will discuss the application of the tests which were found to be suitable for separating these species (Technical Bulletin No. 100) and will include a description of the genus and species.

For a detailed discussion of the classification of this group by earlier writers, reference should be made to the previous bulletins.

During the course of the investigation timely and helpful criticisms have been made by Dr. R. S. Breed of this Station.

DESCRIPTION AND NOMENCLATURE OF THE GENUS *MICROCOCCUS*

The so-called "staphylococci," which are normal inhabitants of the mammalian body, together with the "micrococci," which have generally been considered more or less saprophytic in nature, have been included in this survey and, as no natural division lines could be discovered, both of these groups have been placed together in one group and the term *Micrococcus* as used by Cohn (1872)[1] accepted as the proper generic term for the group.

The term *Staphylococcus* is also available as the name for this genus, but the argument for its selection is based entirely upon usage, especially in connection with the two species *S. aureus* and *S. albus*. The term *Micrococcus* was used by Cohn (1872) prior to the use of *Staphylococcus* by Rosenbach (1884), and while the latter worker only included two parasitic species in his genus, *viz.*, *S. albus* and *S. aureus*, he was followed by Passet who added *S. pyogenes citreus*. Cohn used the generic term *Micrococcus* to include both saprophytes and parasites. The argument from the standpoint of usage for the term *Staphylococcus* is no stronger than the same argument for the term *Micrococcus*, as previous workers have never associated the specific names, *luteus*, *varians*, etc., with the term *Staphylococcus*. For these reasons, there appears to be no justification in this case for disregarding priority.

It is suggested that "staphylococcus" be retained as a trivial or common name to be applied especially to the two species *M. aureus* and *M. albus* which are so commonly considered as "staphylococci".

The genus may be characterized as follows:

MICROCOCCUS Cohn, 1872, p. 148.

Cell division in two or three planes. Generally does not produce regular tetrads or packets. Typically saprophytic or a facultative parasite. May or may not produce red, yellow, or orange pigment. Produces moderate to abundant growth on ordinary nutrient media. Gram positive, variable, or negative. Aerobic or a facultative anaerobe. Does not produce indole. Gelatin often liquefied. Rarely attacks starch. True endospores have not been found. Nitrates often reduced. Motile species have been described. Produces acid but rarely gas from the fermentation of sugars.

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[1]See Bibliography, page 29.

Type species: *Micrococcus luteus*. (Schroeter, 1872, p. 119) Cohn, 1872, p. 153.

The following generic terms, as nearly as can be ascertained from the published descriptions, are synonymous in whole or in part with *Micrococcus* as here described, or have been used for groups of species entirely included in *Micrococcus* as here defined.

Microsphaera Cohn, 1872a.
Merista Van Teigham, 1883.
Staphylococcus Rosenbach, 1884.
Gaffkya Trevisan 1885.
Monococcus Miller, 1886.
Pediococcus Lindner, 1887.
Botryomyces Bollinger, 1887.
Rhodococcus Zopf, 1891.
Pyococcus Ludwig, 1892.
Tetracoccus v. Klecki, 1894.
Planococcus Migula, 1894.
Carphococcus Hohl, 1902.
Albococcus Winslow and Rogers, 1906.
Aurococcus Winslow and Rogers, 1906.
Pedioplana Wolff, 1907.
Melococcus Nedrigailov, 1907.
Peptonococcus Orla-Jensen, 1909.
Liquidococcus Orla-Jensen, 1909.

It has been pointed out (Technical Bulletin No. 100) that this genus is composed of several species and that gelatin liquefaction, chromogenesis, and nitrate reduction form the principal characters for use in separating these species. These characters have been selected, as shown above, because of their constancy and also because of the fact that the resulting groups, when the genus is divided upon this basis, appear to be homogeneous and constant. The use of the term "constant" in connection with bacteria must be relative, as any of the characters of any biological species are subject to more or less natural variation.

DESCRIPTION AND NOMENCLATURE OF SPECIES

From the standpoint of these diagnostic tests the 316 strains studied (Technical Bulletin No. 100) fall into 16 species as outlined below. It will be noted that these species have been based upon cultural characters alone and only in a few instances have serological reactions been taken into account. No study of a group of organisms is complete without a detailed investigation of their serological reiatlon-

ships and such results are now available and will be presented in a later section (Technical Bulletin No. 103). However, some of these results must be anticipated in discussing the formation and characterization of the species of the genus.

The synonomy as suggested below is, of necessity, not always clear, as in many instances the organisms have been inadequately described by the original authors or the descriptions indicate that impure cultures have been studied. This is due to the inadequate methods available to the earlier workers.

Chromogenesis divides the genus *Micrococcus* into four groups of species, *viz.*, yellow, orange, red, and white.

The yellow forms, which have been placed in a separate genus by several workers, represent the central type of the genus and include the type species (*M. luteus*). The orange types are the most strictly parasitic species in the group and are closely followed by the white species, while the red types include more distinctly saprophytic forms.

The **non-liquefying yellow** forms appear to constitute two distinct species as follows:

1. ***Micrococcus luteus*** (Schroeter, 1872, p. 119) Cohn, 1872, p.153.

Saprophytic. Abundant yellow growth on agar slant. Gelatin not liquefied. Nitrates not reduced. Generally inert in milk or produces acid not sufficient to curdle. Can utilize ammonium salts as the only source of nitrogen. Generally Gram negative. Commonly found in milk or milk products. Cells occur in large groups.

Synonym: *Bacteridium luteum* Schroeter, 1872.

2. ***Micrococcus varians*** Migula, 1900, p. 135.

Saprophytic. Abundant yellow growth on agar slant. Gelatin not liquefied. Nitrates reduced. Can utilize ammonium salts as the only source of nitrogen. Generally Gram negative. Variable in action upon milk. Found under a variety of saprophytic conditions. Occurs in large masses. Generally ferments dextrose without the formation of gas.

Synonym: *Merismopedia flava varians* Dyar, 1895.

As nearly as can be determined the following organisms are identical with either *M. luteus* or *M. varians*. It is impossible to determine definitely to which species they belong, as the two are separated upon the basis of nitrate reduction, a character which is not included in the descriptions of the organisms listed below.

Micrococcus citreus agilis Menge, 1892 (in part).

Micrococcus acidi-lactici I, II, III, Conn, 1900.
Micrococcus butyrii Migula, 1900.
Micrococcus butyricus (v. Klecki, 1894) Migula, 1900.
Micrococcus citreus Sternberg, 1893.
Diplococcus commensalis (Turro, 1894.) Migula, 1900 (in part).
Micrococcus cupuliformis Migula, 1900.
Cremfarbigen Micrococcus (List, 1885) Adametz, 1889.
Staphylococcus cereus-flavus Passet, 1885.
Micrococcus flavus Migula, 1900.
Micrococcus flavus Chester, 1901.
Micrococcus excavatus Kern, 1897.
Micrococcus expressus Weiss, 1902.
Micrococcus flavovirens Migula, 1900.
Micrococcus gilvus Losski, 1893.
Micrococcus gilvus Henrici, 1894.
Micrococcus helvolus Henrici, 1894.
Micrococcus Jongii Chester, 1901.
Micrococcus lactis aureus Conn, Esten, Stocking, 1907.
Micrococcus luridus Kern, 1897.
Micrococcus lichenformis Kern, 1897.
Micrococcus Lambkii Migula, 1900.
Micrococcus lactis flavus Conn, Esten, Stocking, 1907 (in part).
Micrococcus lactis citreus B. Conn, Esten, Stocking, 1907.
Micrococcus malolactis Seifert, 1901.
Micrococcus minimus Weiss, 1902.
Micrococcus meldensis Roger, 1898.
Micrococcus ochraceus Rosenthal, 1893.
Micrococcus orbeculatus Wright, 1895 (According to Winslow and Winslow, 1908. page 220.)
Micrococcus piliformis Weiss, 1902.
Micrococcus pallidus Henrici, 1894.
Micrococcus resinaceus, Kern, 1897.
Micrococcus regularis, Weiss, 1902.
Micrococcus siccus Migula, 1900.
Micrococcus subgilvus (Henrici, 1894) Migula, 1900.
Micrococcus strobiliformis Migula, 1900.
Micrococcus stellatus Frankland, 1894.
Micrococcus sulfureus tardigradus (Flügge, 1886) Lehmann and Neumann, 1896.
Micrococcus strobiliformis Lembke, 1897.
Micrococcus tenacatus Chester, 1901.
Micrococcus citreus tetragenus Vincenzi, 1897.
Micrococcus subflavus tetragenus v. Besser, 1889.
Micrococcus flavus tardigradus Flügge, 1886.
Micrococcus tardigradus Migula, 1900.
Micrococcus tardigradus Chester, 1901.
Staphylococcus viridis flavescens Guttmann, 1887.
Micrococcus versicolor Flügge, 1886.

Micrococcus vesiculiferus Migula, 1900.
Micrococcus varians Chester, 1901.
Micrococcus Vincenzii Chester, 1901.
Micrococcus vini I Kramer, 1892.
Micrococcus vini Migula, 1900.
Micrococcus vesicosus Weiss, 1902.
Micrococcus vesiculiferus Lembke, 1897.
Micrococcus V Adametz, 1889.

Some question has arisen in connection with the description of the action of *M. luteus* on gelatin. Cohn in 1872 does not mention this character, but Eisenberg (1891) and later Frankland (1894) definitely associate non-liquefaction with *M. luteus*, and Migula (1900) and the Winslows (1908) refer to it as a non-liquefier. However, Lehmann and Neumann (1896) have classified *M. luteus* as a liquefier, as has Bergey (1923) also. If the original descriptions of Cohn and of those following him, especially the Winslows who worked with a large number of cultures, are to be accepted, the term *M. luteus* must be associated with a non-liquefying and non-nitrate-reducing yellow coccus.

M. luteus and *M. varians* appear to be two separate and distinct species divided largely upon the basis of nitrate reduction which is a constant character among members of this group. Dyar's organism which he called *Merismopedia flava varians* is probably the first description of this non-liquefying, reducing coccus. Certain other cultural characters are, in part, characteristic of each of these species, particularly chromogenesis. *M. luteus* forms a yellow pigment, but the color is generally not as deep and intense as that of *M. varians* which in some cases is almost an orange.

Both of these organisms differ from the more parasitic members of the genus by being able to utilize ammonium salts as the only source of nitrogen. Cohn noted this fact in regard to *M. luteus*, as he found it to grow in solutions containing ammonium acetate as the only source of nitrogen.

The **gelatin-liquefying, yellow** micrococci are separated into three distinct species by the use of the nitrate reduction test and by their relation to the utilization of ammonium salts as a source of nitrogen.

*3. **Micrococcus flavus*** Lehmann and Neumann, 1896, p. 163.

Saprophytic or parasitic. Liquefies gelatin. Does not reduce nitrates. Generally does not ferment mannite or glycerin. Gram variable. Forms large clumps of cells. Generally produces growth when

ammonium salts are furnished as the only source of nitrogen. Produces an abundant yellow growth on agar slant. .

Synonym: *M. flavus liquefaciens* Flügge, 1886.

Organisms probably identical:
Micrococcus badius Lehman and Neumann, 1896.
Micrococcus cupularis Migula, 1900.
Micrococcus corrugatus (Dyar, 1895) Migula, 1900.
Micrococcus conjunctivitidus (Gombert, 1889) Migula, 1900.
Micrococcus citrinus Migula, 1900.
Micrococcus confluens Kern, 1897.
Micrococcus cerinus Henrici, 1894.
Staphylococcus pyogenes citreus Passet, 1885 (in part).
Diplococcus citreus conglomeratus Bumm, 1886.
Diplococcus citreus liquefaciens Unna and Tommasoli, 1889.
Citrongelber Micrococcus Keck, 1890.
Micrococcus corrugata mesenterica Dyar, 1895.
Micrococcus cupularis Lembke, 1897.
Micrococcus flaveus Henrici, 1894.
Micrococcus flavidus Henrici, 1894.
Micrococcus flavescens Henrici, 1894.
Micrococcus gigas Frankland, 1887.
Micrococcus galbonatus Zimmermann, 1890.
Micrococcus granulatus citreus Freund, 1893.
Gelbweisser Diplococcus Bumm, 1886.
Micrococcus citreus liquefaciens Unna, 1900.
Micrococcus lutosus Kern, 1897.
Micrococcus lactis aureus Conn, 1900 (in part).
Diplococcus luteus Adametz, 1888.
Planococcus luteus (Adametz, 1888) Migula, 1900.
Micrococcus mucofaciens Thöni and Thaysen, 1913.
Micrococcus nasalis Hack (according to Eisenberg, 1891).
Micrococcus orbicularis Ravenel, 1896 (in part).
Micrococcus olans Henrici, 1894.
Micrococcus ochroleucus Prove, 1887.
Micrococcus ovalis Kern, 1897.
Micrococcus Pflügeri Ludwig (according to Migula 1900, p. 78).
Micrococcus rugosus Chester, 1901.
Micrococcus subcitreus Migula, 1900.
Micrococcus subflavus (Bumm, 1886) Flügge, 1886.
Micrococcus sub-ochraceus (Lembke, 1897) Migula, 1900.
Micrococcus subgranulatus (Freund 1893) Migula, 1900.
Micrococcus subflavescens Bergey, 1923.
Micrococcus Tommasoli Chester, 1901.
Micrococcus tetragenus-versatilis Sternberg, 1893.
Micrococcus tetragenus-vividus Dyar, 1895.
Micrococcus versatilis (Sternberg, 1893) Chester, 1901.

4. Micrococcus conglomeratus Migula, 1900, p. 146.

Forms large clumps of organisms, many times in pairs. Liquefies gelatin. Varies in acid production in milk, but generally does not produce sufficient acid to curdle. Usually does not ferment mannite or glycerin. Can utilize ammonium salts as the only source of nitrogen. Reduces nitrates. Produces an abundant light yellow growth on agar slants. Gram variable.

Synonyms: *Micrococcus citreus conglomeratus* Flügge, 1886.
Citronengelber Diplococcus Bumm, 1885.
Diplococcus citreus conglomeratus Bumm, 1887.
Micrococcus citreus Winslow and Winslow, 1908.
Merismopedia citreus conglomeratus Dyar, 1895.

According to descriptions the following are probably identical:
Micrococcus aureus lactis Conn, 1900.
Micrococcus casei amori Freudenreich, 1894.
Micrococcus argenteus Lembke, 1897.
Braunen Coccus Maschek, 1887.
Micrococcus baccatus Lembke, 1897.
Micrococcus cremoides Zimmermann, 1890.
Micrococcus citreus lactis Conn, 1900.
Micrococcus chlorinus Cohn, 1872 (Considered a rod by many).
Micrococcus descideus Migula, 1900. Chester, 1901.
Micrococcus expositionis Chester, 1901.
Micrococcus fulvus Cohn, 1875.
Micrococcus fuscus Eisenberg, 1891.
Staphylococcus cereus fulvus Cornil and Babes, 1890.
Grungelber Coccus Maschek, 1887.
Micrococcus lactis minutissimus Conn, Esten, Stocking, 1907.
Micrococcus orbicularis (Ravenel, 1896.) Chester, 1901 (in part).
Micrococcus orbicularis flavus Ravenel, 1896.
Micrococcus percitreus Bergey, 1923.
Micrococcus Uruguae Chester, 1901.
Micrococcus No. 40 Conn, 1894.
Micrococcus, No. 34 Conn, 1894.
Staphylococcus No. 32 Troili-Peterson, 1903.

The nomenclature of this organism has been somewhat confused. Bumm (1885) described a paired, yellow coccus and (1887) named it *Diplococcus citreus conglomeratus* which was changed to *Merismopedia citreus conglomeratus* by Dyar (1895), while Flügge (1886) named it *Micrococcus citreus conglomeratus*. This organism was first given a binomial by Migula (1900) who renamed it *Micrococcus conglomeratus*. In 1908 the Winslows renamed Dyar's organism *M. citreus* and disregarded Migula who had previously named the same organism *M.*

conglomeratus. Migula's combination appears to have priority. Flügge's name cannot be recognized, because it is a trinomial.

5. Micrococcus citreus Migula, 1900, p. 147.

Parasitic. Moderate yellow growth on agar slant. Grows slowly at all temperatures. Generally does not ferment glycerin or mannite. Produces acid coagulation of milk with slight expression of whey. Forms large clumps on laboratory media, but may show short chains or small clumps when freshly isolated. Liquefies gelatin. Reduces nitrates. Gram variable, usually positive. Will not grow when ammonium salts are furnished as the only source of nitrogen.

Synonym: *Staphylococcus pyogenes citreus* Passet, 1885.
Micrococcus pyogenes β citreus Lehmann and Neumann, 1896.
Micrococcus pyogenes Löhnis, 1907.

From the descriptions the following organisms are probably identical:

Micrococcus beri beri Pekelharing and Winkler, 1887.
Micrococcus Biskra Heydenreich, 1888.
Micrococcus flavus conjunctivae Gombert, 1889.
Micrococcus conjunctividis, Migula, 1900.
Micrococcus citreus agilis Menge, 1892 (in part).
Micrococcus E. Barthel, 1910.
Micrococcus epidermis Chester, 1901.
Micrococcus Finlayensis Sternberg, 1893.
Diplococcus flavus liquefaciens tardus, Unna and Tommasoli, 1889.
Micrococcus varians lactis Conn, 1900 (in part).
Micrococcus Lambkii Lembke, 1897.
Micrococcus lactis aureus A Conn, Esten, Stocking, 1907.
Micrococcus mucilaginosus Weiss, 1902.
Micrococcus rugosus Conn, Esten, Stocking, 1907.
Stallluft Bacterium, I, II, Koning.
Micrococcus lactis varians Conn, Esten, Stocking, 1907.
Micrococcus No. 2 Conn, 1894. (According to Chester, 1901, p. 101).

The **orange types** of micrococci are more restricted in their habitat and generally do not show as great a diversity in type as the other forms of this group. They can be divided into two species on the basis of gelatin liquefaction.

6. Micrococcus aureus (Rosenbach, 1884, p. 27) Migula, 1900, p. 135.

Parasitic. Moderate growth on agar slant, becoming orange. Liquefies gelatin. Generally reduces nitrates. Usually Gram positive. Generally ferments lactose and dextrose with the production of acid but no gas. Occurs in pairs and short chains when freshly isolated, but in large

clumps when examined from older cultures. Will not utilize ammonium salts as the only source of nitrogen.

Synonyms: *Staphylococcus aureus* Rosenbach, 1884.
Staphylococcus pyogenes aureus Rosenbach, 1884.
Micrococcus pyogenes aureus (Rosenbach,1884) Migula, 1895.
Micrococcus pyogenes a *aureus* Lehmann and Neumann, 1896.
Micrococcus pyogenes (in part) Löhnis, 1907.
Aurococcus aureus (Rosenbach, 1884) Winslows, 1908.

From descriptions the following organisms appear identical:
Micrococcus albus, (Lindner, 1888) Chester, 1901 (in part).
Micrococcus aureus (Dyar, 1895) Chester, 1901.
Pediococcus albus Lindner, 1888 (in part).
Staphylococcus mastitidis aureus Guillebeau, 1892.
Micrococcus lactis aureus Conn, Esten, Stocking, 1907.
Streptococcus liquefaciens aureus Distaso, 1911 (in part).
Micrococcus aerius Chester, 1901.
Micrococcus of Almquist Sternberg, 1893.
Micrococcus cremoides Dyar, 1895.
Micrococcus conoideus Migula, 1900 (in part).
Micrococcus chryseus Frankland and Frankland, 1887 (Considered by many a rod).
Micrococcus lactis flavus Conn, Esten, Stocking, 1907.
Micrococcus lactis citronus Conn, Esten, Stocking, 1907.
Micrococcus lactis flavus Conn, Esten, Stocking, 1907.
Micrococcus lobatus Migula, 1900.
Aurococcus mollis Winslow and Winslow, 1908.
Merismopedia mollis Dyar, 1895.
Micrococcus mollis (Dyar, 1895) Migula, 1900.
Orangegelb Staphylococcus Gessner, 1883.
Micrococcus pseudosarcina Migula, 1900 (in part).
Micrococcus perflavus Bergey, 1923.
Micrococcus pyogenes Löhnis 1907.
Staphylococcus pyogenes salivarius Biondi, 1887 (in part).
Micrococcus umbilicatius Weiss, 1902.
Micrococcus urinae flavis olearius Doyen, 1885.
Micrococcus No. 2 Conn, 1894.

The history of the use of the names *aureus* and *albus* indicates the confused state of the nomenclature in this particular genus. In 1884 Rosenbach described *Staphylococcus pyogenes albus* and *S. pyogenes aureus* from wounds, using both the trinomials and the binomials *S. aureus* and *S. albus* in his discussion. In 1895 Migula, who did not recognize the name *Staphylococcus*, renamed the organisms *Micrococcus pyogenes albus* and *M. pyogenes aureus*. Lehmann and Neu-

mann (1896), wishing to indicate that they believed both to be varieties of the same species, called these particular types *M. pyogenes* γ *albus* and *M. pyogenes* α *aureus*. Migula, however, in 1900 used binomials calling *M. pyogenes albus*, *M. pyogenes*, while the orange type he called *M. aureus*. In 1908 the situation was further complicated by the Winslows who placed the orange forms in a new genus called *Aurococcus* and the white types in a new genus *Albococcus* with *Aurococcus aureus* and *Albococcus pyogenes* as the type species.

M. aureus as described by Chester in 1901 has a quite different origin. Altho it is probably synonymous with *M. aureus* (Rosenbach) Migula, Chester's name is the binomial which he gave the organism originally described by Dyar (1895) as *M. cremoides aureus*. The term *M. cremoides*, moreover, had been used by Zimmermann (1890), and Migula (1900) retained Zimmermann's name to describe a coccus of rather indefinite characteristics but probably belonging to this orange group.

The use of the term *pyogenes* has been misleading in many cases. Migula, as stated above, used the term *M. pyogenes* to designate the white pyogenic coccus, and later Löhnis (1907) designated all parasitic staphylococci of whatever color as *M. pyogenes*. He further stated that the pathogenic forms of *M. pyogenes* were orange, while the white and yellow forms were merely parasitic or saprophytic.

Another organism which appears to have caused some confusion is *Staphylococcus salivarus pyogenes* as described by Biondi (1887). According to Migula (1900) the chief difference between this particular organism and the common *M. aureus* is in the rate of gelatin liquefaction, together with the density of the pigment formed. Migula recognized this organism as a separate species and named it *M. conoides*. It is probably synonymous in part with both *M. albus* and *M. aureus*.

According to Lux (1903), the organism *Staphylococcus mastitidis aureus* as described by Guillebeau is identical with *M. aureus*.

According to the Winslows (1908), the *M. aureus* group does not reduce nitrates, and they placed the nitrate-reducing orange types in a separate species called *Aurococcus mollis*. In the present work, however, the orange forms have been found to reduce nitrates in practically all cases, and under such circumstances the species *Aurococcus mollis* becomes synonymous with *M. aureus*. The ability of the orange cocci to reduce nitrates has been questioned

by many and even some of the standard text books state that "*Staphylococcus aureus*" does not reduce nitrates. However, after a study of a long series of cultures a non-reducing *M. aureus* was rarely observed.

The other cases of synonomy mentioned in the list appended above are self evident, but it must be kept in mind that in some cases the original descriptions are too meagre to fix the proper relationship of the organism in question.

7. Micrococcus aurantiacus (Schroeter, 1872, p. 119) Cohn, 1872, p. 154.

Saprophytic or parasitic. Moderate growth on agar slant with the production of an orange pigment. Gram variable, generally positive. Does not liquefy gelatin or liquefies very slowly. Generally reduces nitrates. Does not utilize ammonium salts when furnished as the only source of nitrogen. Forms short chains or large clumps.

Synonyms: *Bacteridium aurantiacum* Schroeter, 1872.
Aurococcus aurantiacus (Schroeter, 1872) Winslows, 1908.
Streptococcus aurantiacus-soghi Bruyning, 1898. (According to Chester, 1901, p. 69.)

This species is closely related to *M. aureus*, but differs in its inability to liquefy gelatin, also serologically. *M. aurantiacus*, as will be pointed out later, will not fix complement with or absorb agglutinins from *M. aureus* immune serum. This, together with the cultural differences, indicates that it is a separate species.

The **liquefying, nitrate-reducing white** micrococci include two species which are distinguished largely by their action upon milk.

8. Micrococcus albus (Rosenbach, 1884, p. 21) Buchanan, 1911, p. 196.

Parasitic. Moderate to abundant white growth on agar slant. Gram variable, usually positive. Forms short chains or large clumps. Liquefies gelatin. Reduces nitrates. Does not utilize ammonium salts as the only source of nitrogen. Generally ferments glycerin and mannite. Generally forms an acid curd in milk with the expression of a small amount of whey.

Synonyms: *Staphylococcus pyogenes albus* Rosenbach, 1884.
Staphylococcus albus Rosenbach, 1884.
Micrococcus pyogenes albus (Rosenbach, 1884) Migula, 1895.

Micrococcus pyogenes **γ** *albus* Lehmann and Neumann, 1896

Micrococcus pyogenes Migula, 1900.

Albococcus pyogenes (Migula, 1900) Winslow and Winslow, 1908.

Micrococcus pyogenes Löhnis, 1907, (in part).

From descriptions the following organisms appear identical:

Micrococcus albus (Lindner, 1888) Chester, 1901 (in part).
Pediococcus albus Lindner, 1888 (in part).
Staphylococcus mastidus albus Guillebeau, 1892.
Staphylococcus epidermidis albus Welch, 1891.
Micrococcus ascoformans (Johne, 1884) Chester, 1901.
Micrococcus albicans Trevisan, 1889.
Micrococcus albicans amplus Kruse, 1896.
Streptococcus liquefaciens aurantiacus Distaso, 1911 (in part).
Discomices equi Rivolta, 1884.
Micrococcus aqueus Lembke, 1897.
Micrococcus botryogenes Rabe, 1886 (According to Migula, 1900. page 116).
Micrococcus conjunctivae liquefaciens Gombert, 1889.
Micrococcus endocarditis (Weichselbaum, 1887) Chester, 1901.
Grey white coccus Bumm, 1885.
Micrococcus of gangrenous mastitis in sheep Nocard and Mollereau, 1887.
Micrococcus haemorrhagicus Migula, 1900.
Micrococcus influenzae Fischel, 1891.
Micrococcus lactis varians Conn, 1900 (in part).
Micrococcus liquefaciens Chester, 1901.
Micrococcus liquidus Lembke, 1897.
Micrococcus mastitis Chester, 1901.
Micrococcus madidus Lembke, 1897.
Staphylococcus pemphigi neonatorum Almquist, 1891.
Staphylococcus pyosepticus Hericourt and Richet, 1888.
Micrococcus polymyositis Martinotti, 1898.
Staphylococcus pyogenes sativarius Biondi, 1887 (in part).
Micrococcus pyogenes Migula, 1900.
Micrococcus pseudosarcina Migula, 1900 (in part).
Micrococcus punctatus Lembke, 1897.
Micrococcus quaternus (Seibert, 1894) Migula, 1900.
Micrococcus reesii Rosenthal, 1893.
Micrococcus endocarditidis rugatus Weichselbaum, 1889 (According to Migula, 1900 page 191).
Micrococcus simplex Wright, 1895. (According to Winslows. 1908. page 199).
Micrococcus scariosus (Seibert, 1894) Migula, 1900.

Micrococcus sublilacinus Lembke, 1897.
Micrococcus utriculosis Lembke, 1897.
Micrococcus urinae albus Doyen, 1885.
Micrococcus urinae albus olearius Doyen, 1885.
Micrococcus of Friere, 1885, Sternberg, 1893.
Micrococcus xanthogenicus (Friere) Chester, 1901.
Cryptococcus xanthogenicus Friere, 1885.

Altho similar to *M. aureus* in many respects, *M. albus* has many distinctive characteristics. As will be pointed out later (Technical Bulletin No. 103), these two species differ serologically, as well as in chromogenesis. Many observers have contended that the white pyogenic cocci were only *M. aureus* which had lost the power of pigment production and to substantiate this claim have submitted many cases in which orange types have lost their ability to produce color, making them in all respects resemble *M. albus*. It is true that many orange strains become sluggish in pigment production, but if grown under proper conditions they regain this power while the typically white forms have never been found to acquire this character spontaneously in any degree. *M. albus* appears to be a distinct species and has been listed above as such.

The history of the name has been taken up in the discussion dealing with *M. aureus*, as the two have been closely associated in all work which involves their nomenclature. However, many organisms have been given the name *albus* quite independently of the original use of the term by Rosenbach. Lindner in 1888, in describing an organism from water and beer which produced a dirty white to a pale orange growth, called it *Pediococcus albus*. Chester (1901) revised the name to *M. albus*. Due to the fact that according to the original description this particular organism may form sarcina-like packets, Migula (1900) independently renamed it *M. pseudosarcina*. In all probability Lindner had organisms closely related to the common orange and white forms that had been described by Rosenbach a few years previously. The use of the term *M. albus* by Chester with reference to Lindner's organism raises difficulties as to the calling of the white pyogenic coccus described by Rosenbach by the same name. However, as the specific term *albus* as used by Rosenbach antedates its use by Lindner and as Lindner's organism is probably unidentifiable, it seems desirable to disregard Lindner's term and use *albus* to signify the organisms earlier described by Rosenbach. The actual combination *Micrococcus albus* was probably not used as such to designate this organism until 1911 by Buchanan.

Guillebeau described several organisms from infected mammary glands among which was *Staphylococcus mastitidus albus* which, according to Lux (1903), is identical with *M. albus* (Rosenbach) Buchanan, while Weigmann (1905) thought that Guillebeau's organism was similar to *M. varians* of Conn (1900). Conn, however, in his rather indefinite description of the latter organism, notes its wide variability with reference to chromogenesis and gelatin liquefaction, an observation which rather leads to the conclusion that the name covered more than one species or that impure cultures may have been observed.

Staphylococcus epidermidis albus Welch, 1891, *M. liquefaciens conjunctivae* Gombert, 1899, *M. reesii* Rosenthal, 1893, etc., are no doubt similar to or identical with *M. albus* (Rosenbach) Buchanan, as nearly as can be told from the descriptions. Many workers have isolated *M. albus* as well as *M. aureus* from various human and animal sources and have added a second adjective to the name to signify its original habitat, but there appears to be no good reason for basing species merely on habitat, especially when these are all various parts of the surface of the human or mammalian body. There is every reason to think that all such types are identical, providing there is an agreement in all important characteristics.

9. *Micrococcus casei* n. sp.

Saprophytic. Reduces nitrates. Produces a luxuriant white growth on agar slants. Liquefies gelatin. Produces an acid curd in milk which is rapidly peptonized. Can utilize ammonium salts as the only source of nitrogen. Gram variable, generally positive. Forms large clumps of cells. Usually ferments lactose and dextrose with the production of acid, but with no gas.

Synonyms: *Micrococcus casei liquefaciens* Orla-Jensen, 1904.
Micrococcus casei acido-proteolyticus I Gorini, 1910.

Organisms probably in many respects similar:
Micrococcus acidi lactis Krüger, 1890.
Micrococcus acidificans Migula, 1900.
Micrococcus coranatus Flügge, 1886.
Micrococcus coralloides Zimmermann, 1890.
Micrococcus dissimilus (Dyar, 1895) Chester, 1901.
Micrococcus decolor Lembke, 1897.
Fokker's (1890) Micrococcus.
Micrococcus acidi paralactici liquefaciens Halensis (according to Leichmann, 1896).
Micrococcus Halensis Leichmann, 1896.

Kreideweissverflussigende Micrococcus Keck, 1890.
Liquefying cheese coccus Freudenreich, 1902.
Micrococcus lactis albidus A, B, C, D, E, F, Conn, Esten and Stocking, 1907.
Micrococcus lactis II Flügge, 1886.
Micrococcus liquefaciens Migula, 1900.
Micrococcus liquefaciens acidi I-II Conn, 1900.
Liquefying cheese coccus I Freudenreich and Thöni, 1903.
Micrococcus lactis fluorescens Conn, Esten and Stocking, 1907.
Micrococcus mucilagenous Migula, 1900 (in part).
Micrococcus of bitter milk Conn, 1900.
Micrococcus of slimy milk Stephan, 1890.
Micrococcus rhenanus Migula, 1900.
Micrococcus radiatus Flügge, 1886.
Micrococcus Rhenii Chester, 1901.
Rhine water micrococcus Burri, 1893.
Micrococcus No. IV Ferguson, 1902.
Staphylococcus No. 30 Troili-Peterson, 1903.
Staphylococcus No. 31 Troili-Peterson, 1903.

This species is easily characterized by its acid peptonization of milk and was studied by Gorini in 1902, who isolated but did not name acid proteolytic cocci from the udder. These forms were grouped by him into several types, as were similar cocci isolated by Freudenreich and Thöni (1903). In 1904 Orla-Jensen gave the name *M. casei liquefaciens* to this group. Gorini (1910) gave the names *M. casei acido-proteolyticus I* (gelatin liquefier) and *M. casei proteolyticus II* (gelatin non-liquefier) to a group of proteolytic cocci isolated from milk and cheese. Freudenreich (1902) noted a lemon yellow liquefying coccus and later with Thöni (1903) discussed four distinct types of this organism.

M. casei is an organism very commonly found in milk and dairy products and also in the udder, and may play an important part in the ripening of certain of the harder varieties of cheese.

Binomials have been given to many of the organisms in the above list. These appear to be valid species names, but a careful study of the original description in each case shows certain characteristics which are not similar to *M. casei* or the descriptions are too short to characterize the species definitely. For these reasons the new binomial *M. casei* is suggested.

The **liquefying, non-reducing white** micrococci form a more or less closely related group which can be subdivided on the basis of the utilization of urea as a source of nitrogen.

10. Micrococcus freudenreichii Guillebeau, 1899, p. 135.

Facultative parasite. Liquefies gelatin. Does not reduce nitrates. Variable in acid production from dextrose, lactose, and sucrose. Generally does not ferment mannite or glycerin. Gram variable. Generally does not produce sufficient acid to curdle milk. Cells occur singly or in clumps. Can utilize ammonium salts as an only source of nitrogen.

11. Micrococcus ureae Cohn, 1872, p. 158.

Saprophytic. Cells irregular in shape and size. Occurs singly or in clumps. Liquefies gelatin slowly or not at all. Does not reduce nitrates. Generally does not ferment mannite. Can utilize urea and ammonium salts as an only source of nitrogen. Gram variable, usually negative.

The following organisms are probably identical with one or the other of the above species according to their ability to utilize urea. In the published descriptions of most of the organisms in this list no mention is made of this character.

Micrococcus lactis albus Conn, Esten and Stocking, 1907.
Micrococcus lactis albus A, B, C, D, E, F Conn, Esten and Stocking, 1907.
Micrococcus aethebius (Trevisan, 1889) Chester, 1901.
Streptococcus aethebius Trevisan, 1889.
Micrococcus albidus Losske, 1893.
Micrococcus albatus Kern, 1897.
Micrococcus albescens Henrici, 1894.
Micrococcus albus liquefaciens v. Besser, 1889.
Micrococcus alvi Chester, 1901.
Micrococcus ampullaceus, Kern, 1897.
Micrococcus butyri aromafaciens Keith, 1897.
Micrococcus exiginus Kern, 1897.
Micrococcus glandulosus Weiss, 1902.
Grauer-coccus Maschek, 1887.
Micrococcus communus lactis, Conn, 1900.
Micrococcus lacteus Henrici, 1894.
Micrococcus lentus Lembke, 1897.
Micrococcus nitidus Kern, 1897.
Micrococcus ovis Nocard and Mollereau, 1887.
Micrococcus obsceonus Kern, 1897.
Micrococcus pultiformis Kern, 1897.
Micrococcus subgrioseus Migula, 1900.
Micrococcus sublacteus Lembke, 1897.
Micrococcus sensibilis Zettnow, 1915.
Micrococcus lactis viscosi Grüber, 1908.
Micrococcus ureae liquefaciens Flügge, 1886.

The liquefying, non-reducing white micrococci have many times been considered as identical with *M. albus*, especially in those cases where *M. albus* has been classed as a non-nitrate reducer. In the present work, however, cultures of the *M. albus* type were found to reduce nitrates in a large percentage of cases and under such circumstances the group as represented by *M. freudenreichii* forms a distinct but closely related species.

The organism described by v. Besser (1889) as *M. albus liquefaciens* and renamed by Migula (1900) *M. saccatus* probably belongs to this group. The confusion regarding this particular organism has been due to the fact that Chester (1901) credited the name *M. albus liquefaciens* to Sternberg, altho the latter author plainly gives reference to v. Besser. Chester lists Sternberg's *M. albus liquefaciens* and renames it *M. alvi*. He also lists v. Besser's organism, with a reference to the original description, and names it *M. liquefaciens*. Thus not realizing that the organism listed by Sternberg was that described by v. Besser, Chester gives the same organism two different names. The *M. liquefaciens* of Migula, however, is an entirely different organism and is discussed (page 18) under *M. casei* with which it is probably identical.

Many systematists have felt that *M. ureae* and *M. candidus* are identical, but from a study of several strains of these organisms it is evident that the ability to utilize urea is a fundamental character common only to a particular group or species of cocci. *M. ureae* is primarily a soil form, which is true in a sense also of *M. candidus;* but its peculiar physiological character, together with the irregular size of the individual cells, distinctly separate it from *M. candidus*. *M. ureae* generally liquefies gelatin, altho slowly. This serves as another character to distinguish it from the non-liquefying cocci.

The gelatin **non-liquefying, white** micrococci appear to be very closely related. They are separated upon nitrate reduction and arrangement of cells.

12. ***Micrococcus tetragenus*** Gaffky, 1883, p. 42.

Parasitic. Occurs in tetrads, especially when freshly isolated or from liquid culture. Does not liquefy gelatin. Nitrates not reduced. Moderate white growth on agar slant. Grows best at 37° C. Generally ferments lactose and dextrose. Will not utilize ammonium salts as the only source of nitrogen. Gram positive.

The following organisms are probably very similar or identical as nearly as can be determined from the descriptions:

Micrococcus subflavus v. Besser, 1889.
Micrococcus tetragenus septicus Boutron, 1893.
Micrococcus tetragenus aureus Boutron, 1893 (in part).
Micrococcus tetragenus albus Boutron, 1893.
Micrococcus tetragenus mobilis ventriculi Mendoza, 1889.
Planococcus tetragenus Migula, 1900.
Planococcus tetragenus Chester, 1901.
Micrococcus mendozae Chester, 1901.
Gaffkya mendozae Trevisan, 1889.
Micrococcus tetragenus variabilis Finlay, 1891.
Sarcina tetragenus Migula, 1900.

M. tetragenus, because of its regular grouping, appears to be sufficiently distinct from *M. albus* to be placed in a separate species. However, serologically it cross-agglutinates with *M. albus* and will also fix complement in *M. albus* immune serum, indicating that it is closely related to *M. albus* and should be placed in the same genus.

13. Micrococcus candidus Cohn, 1879, p. 160.

Saprophytic. Forms large irregular clumps. Does not liquefy gelatin. Does not reduce nitrates. Produces moderate to abundant white growth on agar slant. Generally ferments dextrose, lactose, glycerin, and mannite. Usually does not curdle milk. Variable in utilization of ammonium salts as the only source of nitrogen. Gram variable.

14. Micrococcus epidermidis (Kligler, 1913, p. 144) *comb. nov.*

Saprophytic. Forms large irregular clumps. Reduces nitrates. Does not liquefy gelatin. Produces luxuriant white growth on agar slant. Generally ferments lactose, dextrose, glycerin, and mannite. Variable in utilization of ammonium salts as the only source of nitrogen. Gram variable. Generally does not curdle milk.

The following organisms are probably identical with either of the above, depending on their action upon nitrates, which is not stated in all cases:

Micrococcus arborescens lactis Conn, 1900.
Micrococcus aquatilis Bolton, 1887.
Micrococcus aquatilis invisibilis Vaughan, 1892.
Micrococcus achrous Migula, 1900.
Micrococcus achrous Lembke, 1897.
Micrococcus acidi-lactici (Lindner, 1887) Chester, 1901.
Micrococcus albus cereus Passet, 1885.
Pediococcus acidi lactici Lindner, 1887.
Micrococcus albocereus Migula, 1900.
Sphaerococcus acidi lactici Marpmann, 1886.
Micrococcus asper Migula, 1900.

Micrococcus bovis Migula, 1900.
Haematococcus bovis Babes, 1890.
Micrococcus beta (Foutin, 1889) Chester, 1901.
Coccus B Foutin, 1890.
Micrococcus bovinus Migula, 1900.
Micrococcus cyclops Henrici, 1894.
Micrococcus cretaceous Henrici, 1894.
Micrococcus concentricus Zimmermann, 1890.
Micrococcus canescens Migula, 1900.
Micrococcus cumulatus (v. Besser, 1889) Chester, 1901.
Micrococcus cumulatus tenui v. Besser, 1889.
Pediococcus cerevisae Balcke, 1884.
Micrococcus cerevisae (Balcke, 1884) Chester, 1901.
Micrococcus cirrhiformis Migula, 1900.
Micrococcus canus Migula, 1900.
Micrococcus candicans Flügge, 1886.
Micrococcus eburneus Henrici, 1894.
Micrococcus eczemae Chester, 1901.
Federiger Micrococcus Adametz, 1890.
Micrococcus fervitosus Adametz, 1888.
Micrococcus lactis gigas Conn, Esten, Stocking, 1907.
Micrococcus grossus Henrici, 1894.
Micrococcus globosus Kern, 1897.
Micrococcus gelatinogenus Bräutigam, 1891. (According to Migula 1900).
Micrococcus gummosus Happ, 1893.
Micrococcus Hauseri (Rosenthal, 1893) Migula, 1900.
Micrococcus humidus Migula, 1900.
Micrococcus inconspicuous Henrici, 1894.
Micrococcus iris Henrici, 1894.
Micrococcus lactis Chester, 1901.
Micrococcus lactis acidi Leichmann, 1896.
Micrococcus gigantus lactis Conn, 1900.
Micrococcus lardarius Krassiltschik, 1896.
Micrococcus lacticus Migula, 1900.
Sphaerococcus acidi lactici Marpmann, 1886.
Micrococcus acidi lactici Marpmann, 1886.
Micrococcus lucens Van Tiegham, 1883.
Milk white micrococcus Bumm, 1885.
Micrococcus magnus (Rosenthal, 1893) Chester, 1901.
Diplococcus magnus Rosenthal, 1893.
Micrococcus mucilaginous Migula, 1900 (in part).
Micrococcus nivens Henrici, 1894.
Micrococcus nacreaceus Migula, 1900.
Micrococcus nivalis Chester, 1901.
Micrococcus nubilis Migula, 1900.
Micrococcus odorus Henrici, 1894.
Micrococcus odoratus Henrici, 1894.

Micrococcus ovalis Escherich, 1885.
Micrococcus parvus Migula, 1900.
Micrococcus pannosus. Kern, 1897.
Micrococcus proteus Chester, 1901 (According to Winslow and Winslow, 1908).
Micrococcus palleus Henrici, 1894.
Carphococcus pituitoparus Hohl, 1902.
Micrococcus plumosus Brautigam, 1886.
Perlmutterglanzender Diplococcus Tartaroff, 1891.
Micrococcus pseudocerevisae Migula, 1900.
Micrococcus pellucides Kern, 1897.
Micrococcus phosphorescens Cohn, 1872 (Considered by many a rod).
Micrococcus polypus Migula, 1900.
Micrococcus pseudoinfluenzae Migula, 1900.
Micrococcus parvis Lembke, 1897.
Micrococcus roscidis Migula, 1900.
Ranken Coccus Maschek, 1887.
Micrococcus rosettaceous Zimmermann, 1890.
Micrococcus succulentus Henrici, 1894.
Micrococcus sorditus Schröter, 1872.
Micrococcus subcunas Migula, 1900.
Micrococcus Sornthalii Adametz, 1895.
Micrococcus salvarius (Biondi, 1887) Migula, 1900.
Coccus salivarius-septicus Biondi, 1887.
Coccus stellatis Lustig, 1893.
Sterncoccus Maschek, 1887.
Micrococcus stellatus Franklands, 1894.
Micrococcus similis, Dyar, 1895.
Micrococcus serratus Lembke, 1897.
Micrococcus subcanus Lembke, 1897.
Micrococcus tetras Henrici, 1894 (in part).
Micrococcus tardissimus (Trev., 1889; Bumm, 1885) Chester, 1901.
Micrococcus albicans tardissimus Flügge, 1886.
Neisseria tardissima Trevisan, 1889.
Micrococcus albicans tardus Unna and Tommasoli, 1889.
Micrococcus tenacatus Chester, 1901.
Micrococcus tenuis Rosenbach, 1884.
Diplococcus albicans tardissimus Flügge, 1886.
Micrococcus tenuissimus Migula, 1900.
Micrococcus tuberculosis Migula, 1900.
Micrococcus tuberculosis Lembke, 1897.
Micrococcus lactis viscosus Conn, Esten and Stocking, 1907.
Micrococcus vesicae Heim, 1898.
Micrococcus viticulosus Flügge, 1886.
Micrococcus vulgarus Weiss, 1902.
Micrococcus zonatus Henrici, 1894.
Micrococcus No. 43, Conn, 1894.

Micrococcus No. 44, Conn, 1894.
Micrococcus No. 47, Conn, 1894.
Staphylococcus No. 33, Troili-Peterson, 1903.
Micrococcus No. 1 Adametz, 1889.
Micrococcus No. 2 Adametz, 1889.
Micrococcus No. 3 Adametz, 1889.
Micrococcus No. 4 Adametz, 1889.

The nitrate-reducing, non-liquefying form described by Kligler and called *M. epidermidis* is different from *Staphylococcus epidermidis albus* Welch. The latter is a liquefier and probably identical with *M. albus*. *Pediococcus cerviseae* Lindner, 1887, which was found in beerwort, may be similar to *M. epidermidis* (Kligler), as this organism was reported by Dyar (1895) to be a non-liquefier and a nitrate reducer. From the original description, however, it is hard to determine the characteristics of the organism which Lindner described.

M. candidus is probably synonymous with *M. candicans* and, being the older term, is preferred. Cohn (1872) described an organism found in his laboratory which produced a white growth on potato and named it *M. candidus* which Frankland (1895) states is a non-liquefier. Frankland (1895) also has pointed out that *M. candicans* is a gelatin liquefier, but the Winslows (1908) regarded it as a non-liquefier, following Migula (1900).

Bolton (1887) also described a non-liquefying, white coccus which he called *M. aquatilis*, but this being a later description the term becomes synonymous with either *M. candidus* or *M. epidermidis*, depending upon its action upon nitrates.

There is a group of white non-liquefying cocci frequently found in milk that may be included with either of the above species. However, it is doubtful from a study of the descriptions of these forms whether these organisms are true micrococci or whether they are more closely related to *Streptococcus lactis* (Lister) Löhnis, 1907. This group of species has been given several different names, as designated below:

Original Name	Renamed By	Name Given
Sphaerococcus acidi lactici Marpmann, 1886	Migula, 1900	*M. lacticus*
No. 44 Conn, 1894	Chester, 1901	*M. lactis*
Pediococcus acidi lactici Lindner, 1888	Chester, 1901	*M. acidi lactici*
Pediococcus acidi lactici Lindner, 1888	Migula, 1900	*M. pseudocerevisiae*

The organism described by Krüger (1890) as *M. acidi lactici* is a gelatin liquefier and belongs to another group. Marpmann (1886) also described a *M. acidi lactici* and Leichmann a *M. lactis acidi*, which names have remained unchanged. Both of these last-named organisms are gelatin non-liquefiers and, if not identical with *S. lactis*, probably belong either with *M. epidermidis* or *M. candidus*.

The micrococci producing a **red** pigment form a group of organisms which is closely related to the other pigmented forms, yet sufficiently distinct to be regarded as separate species. The production of a red pigment, however, does not warrant their being placed in a separate genus, if the orange and yellow species are not placed in separate genera. The red cocci are probably closely related to some of the red rods, but are differentiated largely upon morphology and probably on serological reactions. The red cocci are divided primarily upon the basis of gelatin liquefaction which appears to give, as a result, two groups which contain closely related strains.

15. Micrococcus roseus Flügge, 1886, p. 183.

Saprophytic. Cells in pairs or large clumps. Generally Gram negative. Generally liquefies gelatin. Can utilize ammonium salts as the only source of nitrogen. Produces moderate to abundant red growth on agar slant. Generally does not curdle milk with acid curd. Variable in relation to nitrate reduction.

According to descriptions the following organisms may be identical:

Micrococcus alpha (Foutin, 1890) Chester, 1901.
Coccus A Foutin, 1890.
Micrococcus corallinus Cantani, 1898.
Micrococcus carneus Zimmermann, 1890.
Micrococcus cerasinus (Eisenberg, 1891) Chester, 1901.
Micrococcus cerasinus siccus Eisenberg, 1891.
Micrococcus carnicolor Frankland, 1894.
Micrococcus cumulatus Kern, 1897.
Micrococcus cerasinus (List) Lehmann and Neumann, 1896.
Micrococcus Dantecii Chester, 1901 (in part).
Micrococcus lactis erthryogenes (Grotenfelt) Conn. Esten and Stocking, 1907.
Micrococcus Erythromyxa Overbeck, 1891.
Merismopedia fragilis Dyar, 1895.
Micrococcus fragilis (Dyar, 1895) Migula, 1900.
Micrococcus haematodes (Babes 1882) Zopf, 1883.
Micrococcus persicus Kern, 1897.
Micrococcus rubinginosus Kern, 1897.
Micrococcus rosaceus Frankland, 1894.
Micrococcus lactis rubidus Conn, Esten and Stocking, 1907.

Micrococcus lactis rosaceus Conn, Esten and Stocking, 1907.
Micrococcus roseus Eisenberg, 1891.
Diplococcus roseus Bumm, 1885.
Micrococcus persicus Migula, 1900.
Roter milch Coccus Keferstein, 1897.
Rosafarbiger Diplococcus Bumm, 1885.
Micrococcus roseus Chester, 1901.
Micrococcus rubeus Chester, 1901.
Micrococcus tetragenus rubeus Bujwid (According to Migula, 1900, page 177).
Micrococcus rubri casei Gratz, 1905.
Micrococcus subcarneus (Kern, 1897) Migula, 1900.
Micrococcus subroseus Migula, 1900.
Micrococcus typhoideus Migula, 1900.

Bumm (1885) described a red coccus which he called *Diplococcus roseus* (according to Chester, 1901), while Migula (1900) refers to Bumm's "Rosafarbiger Diplococcus" and to *D. roseus* Eisenberg. Flügge (1886) redescribed Bumm's organism and called it *Micrococcus roseus* which was followed by Lehmann and Neumann (1896). Chester (1901) independently changes Bumm's *Diplococcus roseus* to *Micrococcus roseus*, while the Winslows (1908) refer to the same organism as *Rhodococcus roseus*. Migula (1900) also designates an organism described by Eisenberg (1891) as *Micrococcus roseus* as *M. subroseus*. It appears that Flügge was the first to transfer this red coccus which was probably first described by Bumm, to the genus *Micrococcus*.

16. Micrococcus cinnebareus Flügge, 1886, p. 174.

Saprophytic. Produces moderate to abundant growth on agar slant. Will not utilize ammonium salts as the only source of nitrogen. Generally does not liquefy gelatin. Usually Gram variable. Generally curdles milk. Forms large irregular clumps of cells.

From the descriptions the following organisms are identical:
Micrococcus bicolor Kern, 1897.
Micrococcus carneus Zimmermann, 1890.
Micrococcus cinnebarinus Zimmermann, 1890.
Micrococcus cerasinus siccus List, 1885.
Micrococcus cerasinus, (Heim, 1898) Migula, 1900.
Micrococcus cerasinus lactis Heim, 1898.
Micrococcus cerasinus (List, 1881) Lehmann and Neumann, 1896.
Micrococcus coccineus Migula, 1900.
Micrococcus Kefersteine Chester, 1901.
Micrococcus latericeus Freund, 1893.
Micrococcus lactericeus (Dobrzyniecki, 1897) Chester, 1901.

Micrococcus lactericeus Dobrzyniecki, 1897.
Roter Coccus Maschek, 1887.
Rhodococcus rhodochrous Zopf, 1891.
Micrococcus rubescens Chester, 1901.
Micrococcus rubellus Migula, 1900.
Micrococcus rubescens Lembke, 1897.
Micrococcus sarcinoidies Migula, 1900.

Several red cocci have been described, particularly from codfish, which grow poorly or not at all on ordinary media. A few strains have been studied which were isolated from this source. It is doubtful if the organisms described by Kellermann (1915) as *M. litoralis* and by Beckwith (1911) as *Diplococcus gadidarum* belong to the species listed here.

The organisms noted in the above lists of synonyms include at least the most important of the micrococci which have been described. The following names have been given to various members of this group, but the descriptions have been too meagre to associate them definitely with any of the species which have been described above:

Micrococcus of progressive abcess formation in rabbits, Koch, 1878.
Micrococcus of pyemia in rabbits Koch, 1878 (According to Sternberg, 1893, p. 803).
Micrococcus of septicemia in rabbits Koch, 1878. (According to Sternberg, 1893 p. 803).
Micrococcus lignithum Renault, 1898.
Micrococcus Gingreardi Renault, 1895.
Micrococcus hymenophagus Renault, 1895.
Micrococcus carbo Renault, 1896.
Micrococcus petrolei Renault, 1897.
Micrococcus casei amari edamicus Raamot, 1906.
Urococcus (six varieties) Miquel, 1888.
Urococcus van Tieghemi Miquel, 1888.
Urococcus Dawdeswelli Miquel, 1888.
Micrococcus chinicus Emmerling and Abderhalden, 1903.
Staphylococcus Leloirii Trevisan, 1889.
Staphylocccus Passettii Trevisan, 1889.
Staphylococcus candidus Warrington, 1888.
Staphylococcus subterraneus Trevisan, 1889.
Micrococcus Loewenbergii Trevisan, 1889.
Micrococcus Burchardti Trevisan, 1889.
Micrococcus sialosepticus Trevisan, 1889.
Micrococcus Doyeni Trevisan, 1889.
Micrococcus melanoglossophorus DeToni and Trevisan, 1889.
Micrococcus cappillorum Trevisan, 1889.
Micrococcus Fickii Trevisan, 1889.
Micrococcus magnus Trevisan, 1889.

Micrococcus opalescens Trevisan, 1889.
Micrococcus commutatus Trevisan, 1889.
Micrococcus porcellorum Trevisan, 1889.
Micrococcus mastobius Trevisan, 1889.
Micrococcus petilus Trevisan, 1889.
Micrococcus haematosaprus Trevisan, 1889.
Micrococcus gelatinosus Warrington, 1888.
Micrococcus nitrificans Van Tiegham, 1883.
Micrococcus Boleti Trevisan, 1889.
Micrococcus crepusculum Cohn, 1872.
Micrococcus mirificus Trevisan, 1889.
Micrococcus putridus Trevisan, 1889.
Micrococcus thermophilus Trevisan, 1889.
Micrococcus decipiens Trevisan, 1889.

CONCLUSIONS

The term *Micrococcus* has been employed to designate the genus of irregular mass-forming cocci and, after a study of a long series of cultures, 16 species have been found which appear to be more or less constant. Gelatin liquefaction, nitrate reduction, and ability to utilize certain ammonium salts as the only source of nitrogen have served as the most important basis for the differentiation of these species.

The species of this genus may be outlined as follows:

KEY TO THE SPECIES OF THE GENUS MICROCOCCUS

A. Pigment produced.
  I. Yellow pigment produced.
    1. Gelatin liquefied.
      a. Nitrates reduced.
        *Utilizes $NH_4H_2PO_4$ as a source of nitrogen.
          M. conglomeratus.
        **Does not utilize $NH_4H_2PO_4$ as a source of nitrogen.
          M. citreus.
      b. Nitrates not reduced.
          M. flavus.
    2. Gelatin not liquefied.
      a. Nitrates reduced.
          M. varians.
      b. Nitrates not reduced.
          M. luteus.

II. Red pigment produced.
1. Gelatin liquefied.
M. roseus.
2. Gelatin not liquefied.
M. cinnebareus.
III. Orange pigment produced.
1. Gelatin liquefied.
M. aureus.
2. Gelatin not liquefied.
M. aurantiacus.

B. No pigment produced.
I. Cells in irregular masses.
1. Gelatin liquefied.
a. Nitrates reduced.
*Utilizes $NH_4H_2PO_4$ as a source of nitrogen. Acid proteolytic action upon milk.
M. casei.
**Does not utilize $NH_4H_2PO_4$ as a source of nitrogen.
M. albus.
b. Nitrates not reduced.
*Utilizes urea as a source of nitrogen.
M. ureae.
**Does not utilize urea as a source of nitrogen.
M. freudenreichii.
2. Gelatin not liquefied.
a. Nitrates reduced.
M. epidermidis.
b. Nitrates not reduced.
M. candidus.
II. Cells in definite tetrads.
M. tetragenus.

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